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Eller et al.

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[54] **TEMPERATURE COMPENSATED PYROTECHNIC DELAYS**

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[52] **U.S. Cl.** .... **102/27 R,** 102/70 R

[51] **Int. Cl.** **F42b 3/10**

[58] **Field of Search** .... 102/27 R, 70 R, 101

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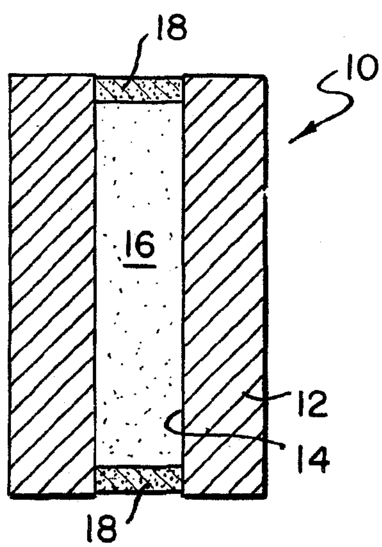
[57] **ABSTRACT**

An improved pyrotechnic delay system wherein temperature compensation is utilized to minimize or eliminate ambient temperature effects upon the burning rate and variability of the delay. The pyrotechnic delay column is surrounded with a volume of material which is easily ignited, high-heat producing, and fast burning relative to the burning rate of the delay column. Heat released by this material heats th body of the delay system, creating an elevated temperature environment for the delay column which is desirable to enhance the predictability of the delay time variable and to minimize adverse effects of the actual ambient temperature. Various configurations are possible in surrounding the delay column with the heat producing material.

8 Claims, 7 Drawing Figures



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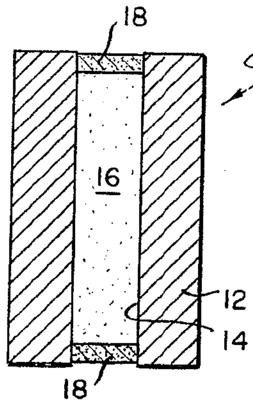

FIG. 1.

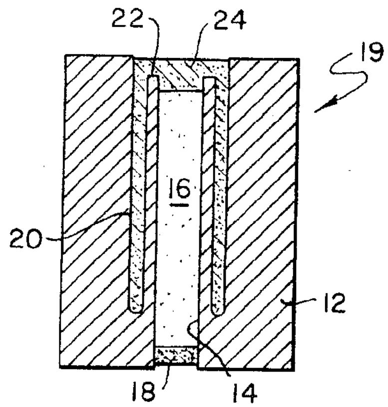

FIG. 2.

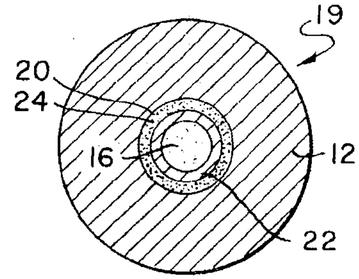

FIG. 3a.

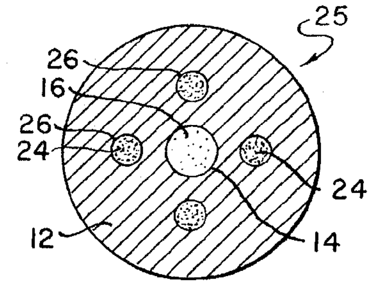

FIG. 3b.

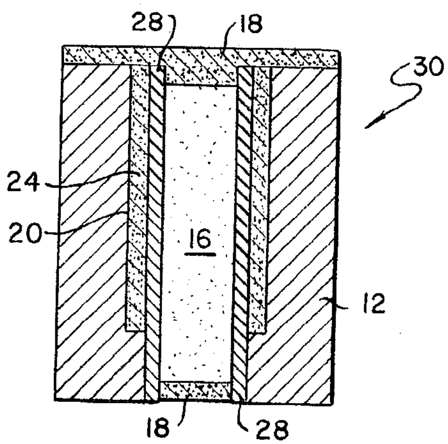

FIG. 4.

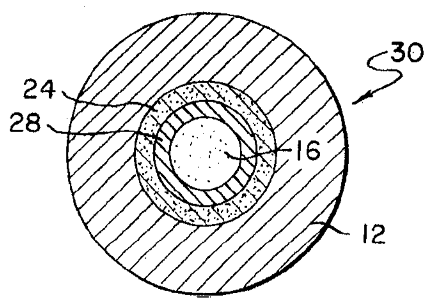

FIG. 5.

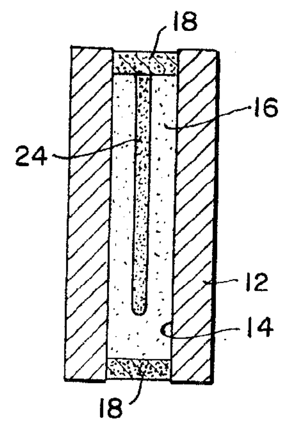

FIG. 6.

TEMPERATURE COMPENSATED PYROTECHNIC DELAYS

BACKGROUND OF THE INVENTION

Pyrotechnic delays, being controlled chemical reactions, are strongly influenced by ambient temperature. Variations in temperature always affect the delay time afforded by such delays and often affect their variability and reliability.

Conventional pyrotechnic delays generally include a delay body, or housing, surrounding the pyrotechnic delay column of suitable composition and an igniter composition for igniting the delay column. During burning, heat is continually being transferred to the delay body from the delay column since the delay column reaction is highly exothermic while the delay body is at a much lower temperature, thus acting as a heat sink. In most situations, this heat transfer to the delay body slows the burning rate of the delay column and hence alters the predictability of the time delay. The burning rates of some widely used tungsten delay compositions and manganese delay compositions may change as much as 15 percent with an ambient change of 76°C. Such large changes may be unacceptable, particularly in precise delay applications such as aircraft ejection systems.

At very low ambient temperatures the heat sink effect becomes more pronounced. Delay columns which are marginally reliable may fail to function due to high heat losses to the delay body.

Most pyrotechnic delay compositions are less temperature dependent at higher ambient temperatures. In other words, a change in temperatures when the ambient temperature is high will produce a smaller change in delay burn time than a temperature change occurring at a lower ambient temperature. Therefore performance of the delay could be enhanced by providing an elevated-temperature environment during delay column reaction.

Slow-burning tungsten delay compositions are preferred over the fast-burning tungsten delays since they are more consistent in performance and have low variability. But fast-burning delays offer the advantages of ease of ignition and speed of reaction. By burning the slower delays at an accelerated rate, the desirable features of both types of delays may be attained.

Furthermore, delay compositions burned in conventional delay bodies are known to have a critical diameter to ensure reliable propagation of burning. This minimum diameter is believed to be a function of heat losses of the delay column. Therefore, the performance of pyrotechnic delays can be greatly enhanced if the heat losses to the delay body can be minimized and the operative temperature environment increased.

SUMMARY OF THE INVENTION

Accordingly, one object of the invention is to provide an improved and more reliable pyrotechnic delay.

Another object of the invention is to provide an improved pyrotechnic delay which is not affected by changes in ambient temperatures, one that is equally efficient and effective at low as well as high temperatures.

Another object of the invention is to provide an improved pyrotechnic delay which is not restricted by a critical diameter of the delay column.

A further object of the invention is the provision of an improved pyrotechnic delay which permits the use of slow-burning, consistent delay compositions at an accelerated burning rate.

Briefly, in accordance with one embodiment of this invention, these and other objects are attained in a pyrotechnic delay body by surrounding the delay column with a volume of composition which is easily ignitable, high heat producing and fast burning with respect to the delay column. The heat produced by the composition pre-heats the delay body and the delay column in advance of the progression of the reaction zone, thus eliminating the heat sink effect between the delay column and the delay body. The elevated temperature environment created by the heating composition substantially negates the effects of ambient temperature, minimizes the influence of ambient temperature changes and permits the delay column to burn more reliably and predictably.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the the accompanying drawings wherein:

FIG. 1 represents a conventional pyrotechnic delay system;

FIG. 2 is one embodiment of the pyrotechnic delay of the present invention;

FIG. 3*a* and 3*b* are top views of the delay of FIG. 2, FIG. 3*b* being an alternative embodiment;

FIG. 4 is another embodiment of the invention;

FIG. 5 is a top view of FIG. 4; and

FIG. 6 is a further embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings wherein like reference characters designate identical or corresponding parts throughout the several views and more particularly to FIG. 1 thereof, pyrotechnic delay **10** is representative of the state of the art. A delay body **12**, fabricated of suitable metal, is provided with a central bore **14** extending therethrough. Positioned within bore **14** is the delay column **16** of suitable pyrotechnic composition, e.g., tungsten delay composition or manganese delay composition. Positioned at both ends of column **16**, as in recesses provided by a foreshortened column, is the igniter composition **18**. At the forward end of the delay column, the igniter composition is ignited by suitable, well-known means, which in turn ignites the delay column. Column **16** burns linearly, the burn time being determined by its length, chemical composition and the ambient temperature in which the delay is operating. Upon reaching the lower igniter composition, the delay column ignites the same, which in turn ignites the ordnance item to which delay **10** is attached.

Burning of column **16** is a highly exothermic reaction and, since delay body **12** is usually of metallic material, the delay body acts as a heat sink, continually conducting heat away from the delay column. This heat transfer affects the burning rate of column **12** and hence alters the delay time afforded by the delay system. The aforesaid phenomenon is aggravated by changes in ambient temperature.

The materials, fabrication methods and other operative features of the above-described delay are known to those skilled in the art and need not be considered in detail hereinafter.

FIG. 2 illustrates one preferred embodiment **19** of the improved pyrotechnic delay of the present invention. Delay body **12,** with central bore **14** containing the delay column **16,** is provided with a reamed passage **20,** concentric with bore **14** and extending approximately the length of delay body **12.** Passage **20** is so formed as to provide a space surrounding central bore **14** with integral, cylindrical shell separator **22** providing retaining means for column **16** and acting as a partition between column **16** and the heating composition **24,** described more fully below. Packed into passage **20** is a pyrotechnic composition **24** which is easily ignited, has a high heat output and is fast burning with respect to delay column **16.** The heater composition, or simply, heater, **24** is ignited by suitable, known means in the same fashion that igniter composition **18** of FIG. **1** is ignited. Column **16** is ignited by heater **24** and since heater **24** is faster burning than the delay column, it is consumed first. The heat thus released heats the delay body **12** to minimize the temperature differential between it and column **16,** thus reducing the heat transfer therebetween. Burning of heater composition **24** also creates an elevated temperature environment for the delay column which is highly desirable inasmuch as most pyrotechnic delay compositions are less temperature dependent at higher operating temperatures.

Separator **22** prevents direct reaction contact between column **16** and heater **24** but at the same time serves as a good heat conductor. It should be noted, however, that the type of heater composition selected should be such that the temperature created during burning, as experienced at the delay column, is below the auto-ignition temperature of the delay column. As shown in FIG. **2,** heater composition **24** may be the same as igniter composition **18,** for example A1A. Use of igniter composition as the pyrotechnic compound is desirable since such material is readily available, its performance characteristics are well documented and it fulfills the requirements of easy ignitability and high heat output. However, any other suitable material may be used provided the reaction temperature as experienced at the delay column is below the auto-ignition temperature of the delay column.

For maximum effect, the delay body **12** should be of a highly thermally conductive material and the separation between heater **24** and column **16** should be minimized. In general, the delay body thermal conductivity should increase and the separation distance should decrease as the nominal, temperature- uncompensated delay reciprocal burning rate decreases, i.e., as the ratio (sec. / in.) decreases, or a faster-burning delay column.

In addition to minimizing the heat sink effect of the delay body with the numerous benefits attendant thereto and reducing the effect of ambient temperatures upon delay system performance, the elevated-temperature environment created by the heater composition yields several other advantages with respect to improved pyrotechnic delay performance. Temperature compensation of the delay system generally accelerates the burning rate of the delay column, the acceleration being determined from test data. Accelerated burning permits use of very consistent, slow-burning tungsten delay compositions of low variability while achieving the speed and ease of ignition of a fast-burning delay. Temperature compensation allows increasing the burning rate beyond that currently attainable of some conventional delay compositions which already possess highly desirable performance characteristics. Also, temperature compensation allows usage of longer delay columns, providing a means of changing column length for a given time delay without changing delay composition. This is highly desirable when delay systems must meet physical design constraints.

FIG. *3a* is a top view of FIG. **2** with the top layer of heater composition **24** removed for greater clarity. FIG. *3b* is a top view of an alternative embodiment **25** of the delay system of FIG. **2.** Instead of a passage concentric with central bore **14,** a plurality of holes **26** are provided in delay body **12** surrounding delay column **16.** Heater composition **24** is packed into holes **26** with a layer distributed over the top surface of the delay (not shown in FIG. *3b*). Of course a layer of igniter composition is clearly an equivalent alternative. Ignition of this top layer permits simultaneous ignition of all of the heater composition - filled holes **26** and delay column **16.** The embodiment of FIG. *3b* operates in the same fashion as the delay of FIG. **2.**

The embodiment **30** of the pyrotechnic delay shown in FIG. **4,** of which FIG. **5** is a top view, minimizes heat loss from the delay to the surroundings. In this delay system, the delay body **12** is of a thermally insulative material to prevent heat loss therefrom. Delay column **16** is surrounded by a tubular portion **28** of the delay body made of a highly thermally conductive material. As in the delay of FIG. **2,** a passage **20** is provided concentric with column **16** which is packed with heater composition **24.** Ignition composition **18,** which may be the same material as heater composition **24,** is deposited on the upper surface of delay **30** and below the delay column **16.** After ignition, delay **30** functions are described hereinabove for the delay system of FIGS. **2** and 3b. Heat released by heater composition **24** is readily transferred to column **16,** via the conductive portion **28** but the heat from heater **24** and column **16** are retained within the delay system **30** by the insulative nature of body **12.**

FIG. **6** is a further embodiment of the invention. Packed within a central bore **14** of delay body **12** is the delay column **16,** terminated at both ends with igniter composition **18.** Centrally positioned within column **16** is a column of heater composition **24,** suitably encapsulated or otherwise contained to prevent direct reaction contact with the delay column. For example, heater composition **24** may be swaged within a lead tube. Delay column **16** and heater composition **24** are simultaneously ignited by igniter **18.**

For nonlinear delay configurations, such as those used in some setable fuzes, orientation of the heater composition should follow the delay configuration.

The foregoing examples are illustrative only. Many other delay column - heater composition configurations are possible within the scope of the invention. The compositions of the delay column and heater as well as the igniter are matters of choice within the criteria set forth hereinabove. The igniter may be ignited before, simultaneous with or after the delay column is ignited.

Obviously, numerous modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described herein.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A temperature-compensated pyrotechnic delay system comprising:
   a containment member;
   first pyrotechnic means within said member;
   an easily ignited, faster-burning, exothermic second pyrotechnic means within said member; and
   ignition means to initiate a reaction in said first and said second pyrotechnic means whereby said second pyrotechnic means produces an elevated temperature condition in said delay system.

2. The delay system of claim 1 wherein said first pyrotechnic means is a delay column having a determinable burn rate.

3. The delay system of claim 2 wherein said ignition means includes an igniter compound easily ignited.

4. The delay system of claim 3 further comprising:
   a bore extending through said containment member;
   a longitudinal passage in said containment member; and
   a heat conductive separation means between said bore and said passage
   whereby said delay column is positioned in said bore and said exothermic compound is positioned in said passage such that during pyrotechnic reaction, heat released by said exothermic compound is conducted to said delay column and said containment member.

5. The delay system of claim 4 wherein said passage is concentric with said bore and said separation means comprises a tubular portion of said containment member.

6. The delay system of claim 4 wherein said passage comprises a plurality of longitudinally extending holes in said containment member spaced around said bore and said separation means comprises the portion of said containment member between said holes and said bore.

7. The delay system of claim 4 wherein said passage is concentric with said bore, said separation means comprises a tubular element of thermally conductive material, and said containment member is of thermally insulative material.

8. The delay system of claim 4 wherein said passage comprises a tubular element of thermally conductive material positioned within said delay column.

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